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ENGINEERING DATA TRANSMITTAL

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1	/	Cog. Eng. M. Kummerer	<i>M. Kummerer</i>	9/25/92	H5-32	R. D. Crowe	<i>R. D. Crowe</i>	9/25/92	H5-32	1	1
1	/	Cog. Mgr. J. M. Grigsby	<i>J. M. Grigsby</i>	9/25/92	H5-32	V. C. Boyles	<i>V. C. Boyles</i>	9/25/92	R1-49	4	
1	/	QA D. C. Board	<i>D. C. Board</i>	9/25/92	S1-57	S. M. Stahl	<i>S. M. Stahl</i>	9/25/92	H5-31	4	
1	/	Safety M. N. Islam	<i>M. N. Islam</i>	9/25/92	H5-308	R. J. Cash	<i>R. J. Cash</i>	9/25/92	R2-32	1	1
1	/	Env. L. P. Diediker	<i>L. P. Diediker</i>	9/25/92	T1-30	R. E. Raymond	<i>R. E. Raymond</i>	9/25/92	R1-30	1	1
1	/	G. M. Christensen	<i>G. M. Christensen</i>	9/25/92	H4-21	TFOSubcouncil/Chairman	<i>TFOSubcouncil/Chairman</i>	9/25/92	RHM	1	
4	/	G. L. Borsheim	<i>G. L. Borsheim</i>	9/25/92	R2-11	See page 2 for signature					

18. M. Kummerer Signature of EDT Manager 9/25/92 Date	19. R. J. Cash Authorized Representative for Receiving Organization 9/25/92 Date	20. J. M. Grigsby Cognizant/Project Engineer's Manager 9/25/92 Date	21. DOE APPROVAL (if required) Ltr. No. <input type="checkbox"/> Approved <input type="checkbox"/> Approved w/comments <input type="checkbox"/> Disapproved w/comments
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7. Abstract This safety assessment examines the existing safety analysis of interim stabilization of single shell tanks, and discusses additional potential hazards arising from the reactive nature of the waste components in ferrocyanide tanks.		
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Additional Information

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LIST OF TERMS

(CN ⁻)	cyanide ion
CTMS	continuous temperature monitoring system
DCRT	double-contained receiver tanks
EDE	effective dose equivalent
FIC	Food Instrument Corporation
HEPA	high-efficiency particulate air
JCO	justification for continued operation
LFL	lower flammability limit
LOW	liquid observation wells
MLD	master logic diagram
SST	single shell tanks
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
USQ	Unreviewed Safety Question
WHC	Westinghouse Hanford Company

END SHEET

SAFETY ASSESSMENT FOR INTERIM STABILIZATION OF FERROCYANIDE TANKS

1.0 SCOPE

This safety assessment addresses interim stabilization of eight Hanford Site single-shell tanks (SSTs) that are on record as containing greater than 1,000 mol of ferrocyanide. The eight ferrocyanide tanks that require interim stabilization are BX-106, BX-110, BX-111, BY-103, BY-105, BY-106, T-101, and T-107.

1.1 PURPOSE OF SAFETY ASSESSMENT

In the interest of reducing the amount of radioactive liquids available for release to the environment from potential tank leaks, Westinghouse Hanford Company (WHC) is pursuing a program for interim stabilization and isolation of all Hanford Site SSTs. A tank is considered to be interim stabilized if it contains less than 5,000 gal of supernate and less than 50,000 gal of drainable interstitial liquid associated with the waste solids. In addition, if a tank is jet pumped, the pumping flow rate has to be below 0.05 gal/min before pumping is complete (Hanlon 1992). Isolation of the tanks involves closing off all pathways by which additional wastes could be introduced to the tanks.

Supernates are typically removed by a submersible pump. Removal of the interstitial liquid contained in the waste solids is achieved by a process called salt well jet pumping. The residual liquid left in the tank after this process is largely held in the solids by physical and chemical forces. Therefore, the amounts available to drain through a breach in the tank below the remaining liquid level would be very small.

In 1990, WHC declared an Unreviewed Safety Question (USQ) with respect to tanks containing significant amounts of ferrocyanide because the analyzed safety envelope in the facility safety analysis reports did not show that potential accidents involving the tanks' contents had been bounded. A watchlist was established to include 24 tanks that, at the time, were thought to contain at least 1,000 mol of ferrocyanide. Because an USQ exists for these tanks, any activity that involves opening the confinement boundaries of the tanks is restricted until the safety of the activity has been thoroughly examined. Pumping to achieve interim stabilization is such an activity.

Commitments under the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) (Ecology 1989) require that all 149 SSTs be interim stabilized by September 1996. To date, 105 of the 149 SSTs have been interim stabilized. The process is nearly completed for an additional five tanks. Of the 24 tanks on the ferrocyanide watchlist, 17 were either interim stabilized by salt well jet pumping before the USQ was declared or were judged to contain too little free liquid to require pumping (administratively stabilized). To meet the Tri-Party Agreement commitment, the safety of interim stabilizing the remaining 8 ferrocyanide tanks must be established.

Aside from the committed schedule discussed above, WHC must be prepared to commence pumping a tank as soon as safely possible after it has been identified as an assumed leaker. The *Single-Shell Tank Leak Emergency Response Guide* (Lo 1991) outlines actions to be taken. For a tank that is on the watchlist, pumping preparations would be made. Work in the tank, including the pumping operations, would require a readiness review. For a tank involving a USQ, the readiness review requirements would include a safety assessment. This document fulfills that requirement for the eight subject ferrocyanide tanks.

An additional USQ has been declared with respect to the risk from nuclear criticality for the tanks. The justification for continued operation (JCO) in response to that USQ placed an administrative hold on pumping of liquid waste from the SSTs to accomplish interim stabilization (Gerton 1992). It requires that the effect of removing supernatant moderator be evaluated and, if necessary, that administrative and operational controls to minimize risk and ensure the safety of these operations be established. Therefore, pumping of the ferrocyanide tanks will not proceed until that evaluation is completed.

Alternatives to interim stabilization by salt well jet pumping have been proposed. The "no action" option, which would permit the SSTs to leak their contents to the ground, is unacceptable in light of existing commitments to prevent further contamination of Hanford Site soils. Furthermore, the moisture content of ferrocyanide waste is an important consideration for continued safe storage. Loss of liquid through a tank leak is expected to have a similar effect on the waste stability as interim stabilization by jet pumping. However, the loss by leakage would be uncontrolled.

Other alternatives to salt well jet pumping are: (1) engineered barriers around the tanks to fix or confine the leaking wastes in a limited volume of soil and (2) in-tank solidification of the wastes by processes such as glassification. The extent of technology development necessary to realize either of these options prevents their usefulness for the near-term minimization of releases to the environment. They have not been ruled out as long-term options, however.

1.2 BACKGROUND OF FERROCYANIDE TANKS

Ferrocyanide ion and nickel additions were used in early waste reduction campaigns at the Hanford Site to precipitate radioactive cesium (as cesium nickel ferrocyanide) from waste solutions so that low-activity supernate could be removed. The process used also included the means to remove radioactive strontium from the waste streams.

The ferrocyanide precipitate in the tanks is primarily disodium nickel ferrocyanide $[\text{Na}_2\text{NiFe}(\text{CN})_6]$. It is diluted with the other solids that were also brought down when the solution was made alkaline to precipitate the ferrocyanide, notably iron hydroxide, strontium phosphate, and sodium salts of phosphate, sulfate, and nitrate.

The recipe for the precipitation process varied slightly for different campaigns. However, the sludges fall roughly into three categories: U Plant, T Plant, and In-Farm. Of these, the In-Farm waste is significantly more

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concentrated in ferrocyanide than the other two because the treated waste had previously been in an alkaline state and had lost most of the other components that serve to dilute the other wastes. The tanks that are the subject of this safety assessment all contain wastes from the U Plant process.

Subsequent to the ferrocyanide campaigns, other wastes were added to some of the tanks. Later additions to some of the tanks were in the form of supersaturated, partially crystallized, alkaline solutions remaining from waste concentration, another waste reduction process. These solutions also contained alkaline insoluble hydroxides and hydrated oxides produced when the acidic waste solutions were made alkaline for storage in the carbon steel-lined tanks. The hot concentrated waste was pumped on top of the ferrocyanide sludge layer. As it cooled the crystals settled making a cake of salt saturated with mother liquor.

To obtain more information about the expected composition and behavior of the ferrocyanide tank contents, laboratory scale tests have been performed using nonradioactive simulants made up from the original process flowsheets. Tests to determine the energetics of the ferrocyanide salts in the presence of nitrate oxidant were completed (Bechtold 1992 and Fauske 1992). Other tests to investigate the hydraulic properties of the sludge have been performed (Wong 1992). In addition to the testing of waste simulants, samples from one tank, C-112, have been tested.

1.3 FERROCYNANIDE TANKS REQUIRING INTERIM STABILIZATION

Of the 24 ferrocyanide watchlist tanks, 17 had been interim stabilized, either by administrative review or by pumping, before the USQ was declared. Seven tanks remain that do not meet interim stabilization criteria. They are BX-106, BX-111, BY-103, BY-105, BY-106, T-101, and T-107. One additional tank, BX-110, was jet pumped in 1985 and declared interim stabilized. However, further pumping may be required because calculation of remaining drainable liquid may not have been correct. The tank has no liquid observation well (LOW) for monitoring the interstitial liquid level. Therefore, Tank BX-110 is included in the scope of this safety assessment.

After the ferrocyanide watchlist was established, an investigation was conducted into the records of the ferrocyanide campaigns (Borsheim 1991). It revealed that the inventory data used to assign tanks to the watchlist was very likely to be in error for many of the 24 tanks.

On the basis of that investigation, it is now thought that BX-106, BX-110, BX-111, and T-101 do not contain the requisite amount of ferrocyanide and, therefore, should not be on the ferrocyanide watchlist. However, since they have not yet been formally removed from the list, they are included in this safety assessment with the assumption that they contain at least 1,000 mol of ferrocyanide.

Each of the tanks, except BX-106, has a salt well screen already installed. Tank BX-106 contains a few feet of solid waste with 15,000 gal of supernate. Stabilization criteria can be met with supernate pumping only. Therefore, jet pumping of that tank is not required.

Results of chemical analysis of supernate samples from the BX and BY tanks examined in this safety assessment are available. They are summarized in Table 1.

Table 1. Analysis of BX and BY Tank Supernate Samples.*

Tank	Specific gravity	pH	H ₂ O (%)	TOC (g/L)	CN ⁻ (μg/g)	NO ₃ ⁻ (M)	⁹⁰ Sr (μCi/L)	¹³⁷ Cs (μCi/L)
BX-106	1.33	13.28	63.8	4.4	NA	2.62	5.16 E+02	1.81 E+05
BX-110	1.37	12.5	56.6	5.6	NA	5.04	1.50 E+01	1.35 E+05
BX-111	1.44	12.7	53.3	5.7	NA	2.62	2.00 E+01	2.60 E+05
BY-103	1.45	13.29	52.0	2.73	6.73	4.37	2.33 E+02	2.00 E+05
BY-105	1.39	13.24	54.3	2.93	14.57	8.42	1.30 E+01	7.40 E+04
BY-106	1.46	13.47	49.6	3.16	45.38	4.05	1.20 E+02	3.11 E+05

*Data reproduced from Grigsby 1992.

NA = not available.

TOC = total organic carbon.

2.0 DESCRIPTION OF ACTION

2.1 GENERAL INFORMATION

The WHC Waste Stabilization and Isolation Program requires the removal of supernate and drainable interstitial liquid from solid wastes in SSTs. This is accomplished by salt well pumping using jet pumps. The pumped liquid waste is transferred to double-contained receiver tanks (DCRT) at low pumping rates. The liquid accumulated in the DCRT is eventually transferred to double-shell storage tanks or is sent into the waste concentration system for volume reduction. Figure 1 provides a simplified representation of a typical Salt Well-DCRT System.

2.2 SYSTEM INFORMATION

In general, the process facilities and equipment needed for the interim stabilization by salt well jet pumping of the SSTs are:

1. Single-shell waste storage tank
2. Pump pit, salt well screen, jet pump assembly, and jet pump jumper assembly
3. Transfer piping and valve pits
4. Double-contained receiver tanks

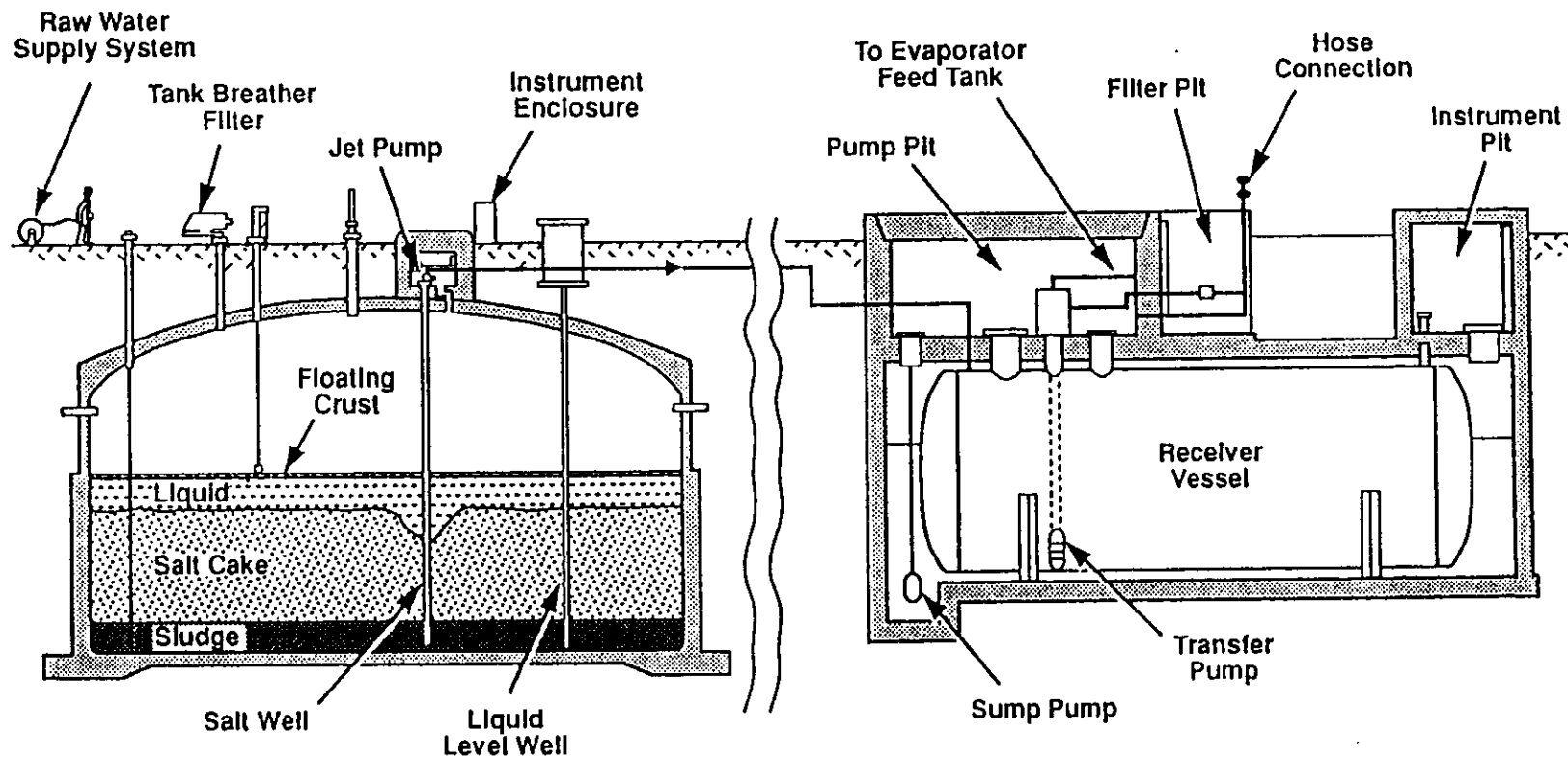


Figure 1. Typical Salt Well-DCRT System.

5. Associated instrumentation, alarms, and controls
6. Double-shell waste storage tank.

2.2.1 Single-Shell Waste Storage Tanks

The underground single-shell waste tanks considered in this safety assessment are two sizes. Tanks in the BX and T Tank Farms have a nominal capacity of 530,000 gal, while the capacity of the BY Tank Farms is 750,000 gal. The tanks are constructed of reinforced concrete with a mild steel liner covering the bottom and sidewalls. Figure 2 shows a schematic of these two types of tanks.

All of the SSTs have been inactive since 1980. Therefore, no waste transfers into the tanks included in this safety assessment have been made since that time, and none are planned for the future. All the subject tanks are passively ventilated through a riser with high-efficiency particulate air (HEPA) filtration.

Temperature readings from thermocouples at various depths in the waste are taken and recorded manually once a week. In the BY Farm, tank thermocouples are also connected to a continuous temperature monitoring system (CTMS). Temperatures are recorded every 15 minutes.

Various level measuring techniques are used to monitor total waste and interstitial liquid levels. Tanks BY-103, BY-105, BY-106, and BX-111 have LOW in which a combination of neutron and gamma ray scanning is used to determine interstitial liquid level. The waste level in these four tanks is taken manually by tape. Tank BX-110 has no LOW and the waste level in this tank is also read manually from tape. The other three tanks are equipped with Food Instrument Corporation (FIC) level gauges. In Tank BX-106 the level readings are taken manually. In tanks T-101 and T-107, the FIC gauge readings are transmitted to an automatic data recording system.

2.2.2 Salt Well and Jet Pump

The equipment and installations required at the SST for jet pumping from the salt well are: (1) a pump pit, (2) a salt well screen, (3) a jet pump assembly consisting of a centrifugal pump and jet assembly, (4) jet pump jumpers, and (5) associated instrumentation and controls.

The dome of each SST is penetrated by several risers, one of which protrudes into a pump pit. A pump pit is a concrete structure located above the tank dome near the center of the tank. The jet pump system is housed within the pump pit with portions of it extending down into the riser. Figure 3 shows a typical salt well jet pump system.

The salt well jet pump system includes an 8- or 10-in.-diameter salt well casing consisting of a salt well screen welded to schedule 40 carbon steel pipe. The casing and screen are inserted into a 12-in. tank riser located in the pump pit. They extend through the tank waste to near the bottom of the tank.

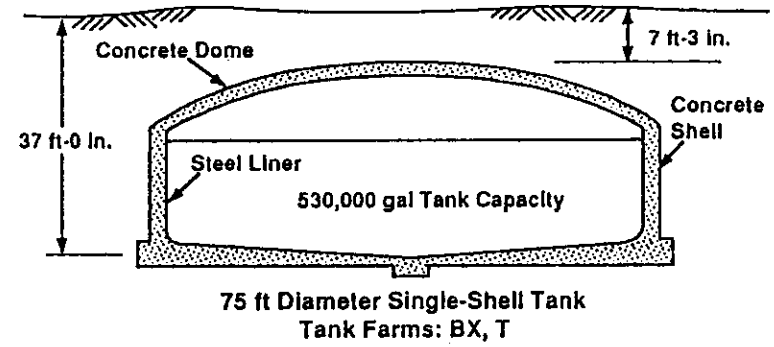
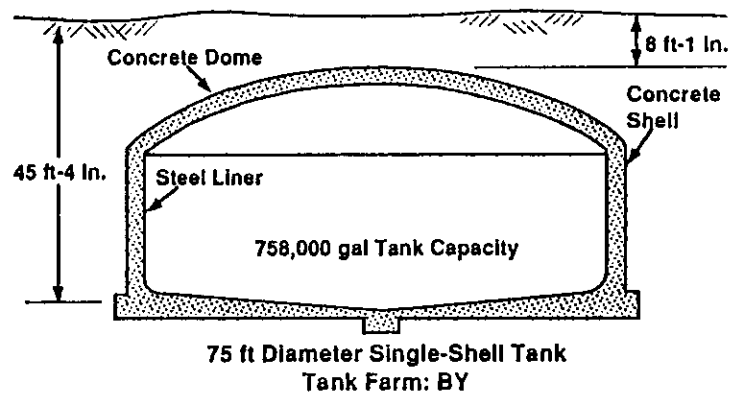
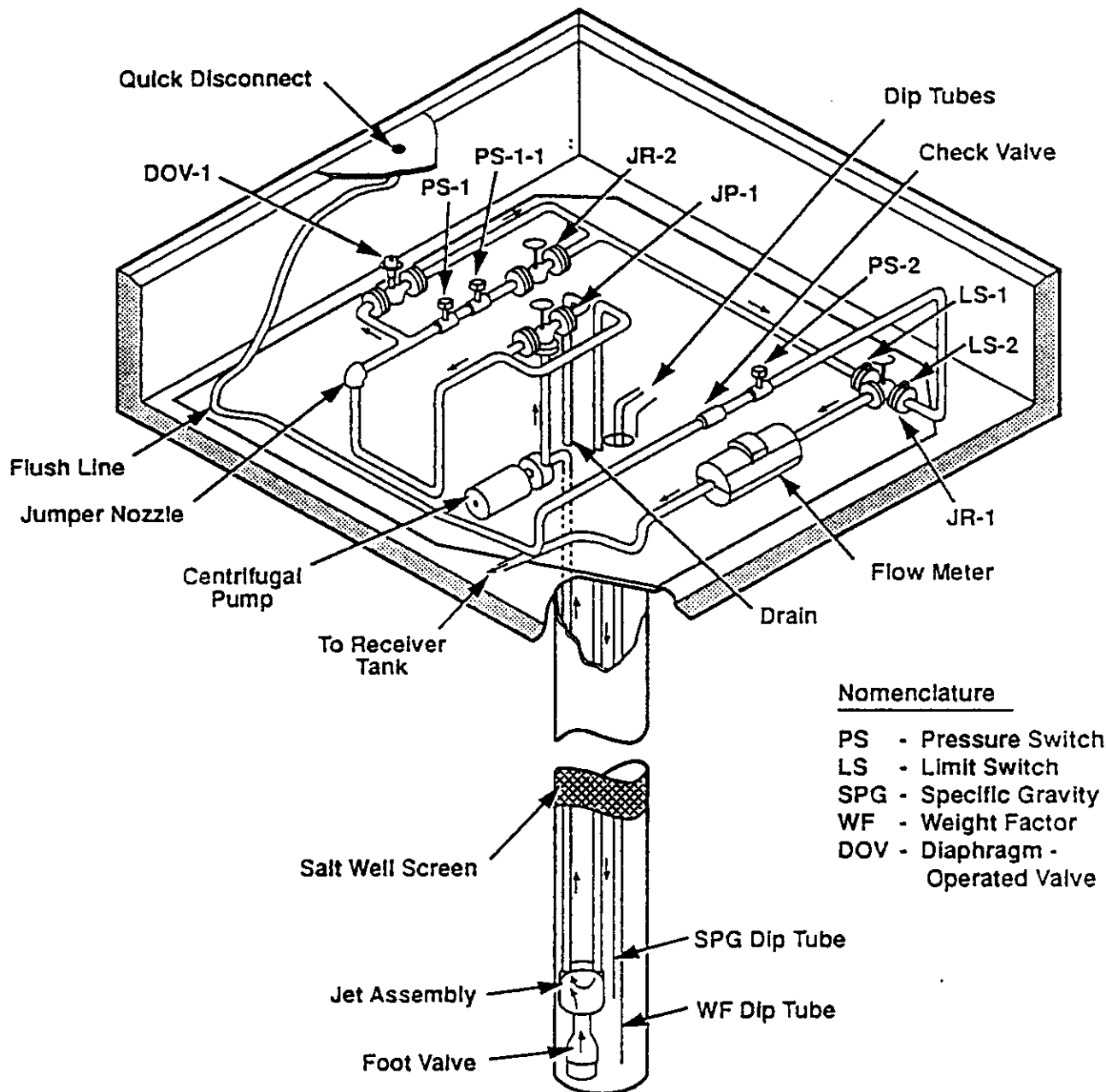


Figure 2. High-Level Waste Tank Configuration.

Figure 3. Typical Salt Well Jet Pump.



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The salt well screen consists of a length of 300-series, 8- to 10-in.-diameter stainless steel pipe with screen openings (slots) of 0.05 in. A jet assembly with foot valve is mounted to the base of two pipes that extend from the top of the well to near the bottom of the well casing inside the salt well screen. The salt well screen also holds dip tubes for measuring specific gravity and weight factor of the liquid. All of the tanks included in this safety assessment have salt well screens installed except for Tank BX-106 (Lo 1991). Since interim stabilization could be accomplished in that tank by pumping off the 15,000 gal of supernate, salt well pumping may not be required.

The components of the jet pump system located within the pump pit include a centrifugal pump to supply power fluid to the down-hole jet assembly, flexible or rigid jumpers, a flush line, and a flowmeter. The jumpers contain piping, valves, and pressure and limit switches. Instrumentation and control devices are also located within the pump pit. A drain in the bottom of the pump pit empties into the tank and is normally open.

The centrifugal pump and jet assembly are needed to raise the interstitial liquid from the salt well screen into the pump pit, nominally a 40-ft elevation rise. The centrifugal pump, rated at approximately 30 gal/minute at 30 psig, pressurizes power fluid to the jet assembly located in the salt well screen. The power fluid passes through a nozzle in the jet assembly and acts to convert fluid pressure head to velocity head, thereby reducing the pressure in the jet assembly chamber. The reduction in pressure allows the interstitial liquid to enter the jet assembly chamber and mix with the power fluid. Velocity head is converted to pressure head above the nozzle, lifting power fluid and interstitial liquid to the pump pit. Pumping rates vary from 0.05 gal to about 4 gal/minute.

Raw water is used to fill the salt well jet pump system loop and prime the pump for operation. A recirculation loop permits the prime on the pump to be maintained at very low pumping rates. The energy produced by the pump's operation can heat the recirculated liquid about 30 °F above tank temperatures.

Important instrument and control systems at the tank associated with salt well pumping include: (1) leak detection; (2) jet pump system controls, including limit switches and safety interlocks; and (3) weight factor and specific gravity measurement.

Leak detection is provided in each pump pit in the salt well system. Leak detection in a single pit is interlocked to shut down the pump in that pit as well as all pumps on the same manifold. A flashing light and an audible alarm, located on top of the pump control station outside the pump pit area, alert tank farm operators to the shutdown condition.

Up to four salt well pumps are connected by manifold to a common waste transfer line. The pumps are interlocked to provide safe and orderly shutdown of the group in the case of an unplanned event. The interlocks that shut down the pumps include: (1) loss of pump outlet pressure, (2) excess pressure in the flush leg, (3) high pressure in the circulation loop, (4) leak detection in the pump pit, (5) area radiation detection, (6) leak detection in a DCRT, and (7) DCRT at maximum operating level.

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Dip tubes, extending into the liquid waste through the salt well casing, are used to measure the weight factor and specific gravity. From these measurements the liquid level in the salt well screen is determined. Controllers are set to control the liquid level a fixed amount above the jet intake.

2.2.3 Transfer Piping and Valve Pits

Transfer lines designated for transfer of waste from the BX, BY, and T Tank Farms to the double contained receiver tanks are direct buried lines with 3 ft of ground cover to provide shielding. These lines are carbon steel welded pipe, 1 to 3 in. in diameter. All transfer lines are sloped for drainage.

The design life of all salt well pumping transfer lines is five years. They are now more than 10 years old. Therefore, the lines must be pressure tested before use and every six months during use to ensure against leaks. The requirement is that the lines must have been tested within the six-month period prior to their use. Procedure TO-140-170 (WHC 1990) describes the method of pressure testing.

Flow from the tanks to the receiver tank is routed through a valve pit. There the flow from the sending tanks' transfer lines is routed through a manifold to the receiving tank line by a series of valves and jumper connections. Two- and three-way valves are built into each jumper to divert the flow where needed. Valve pits are concrete boxes with heavy cover blocks. Leak detection in the valve pit is interlocked with corresponding pumps. A drain line in the valve pit connects to a flush pit.

2.2.4 Double-Contained Receiver Tanks

Salt well waste from the BX and BY tank farms will be accumulated in DCRT BX-244. The salt well waste from the T Tank Farms will go to the TX-244 DCRT.

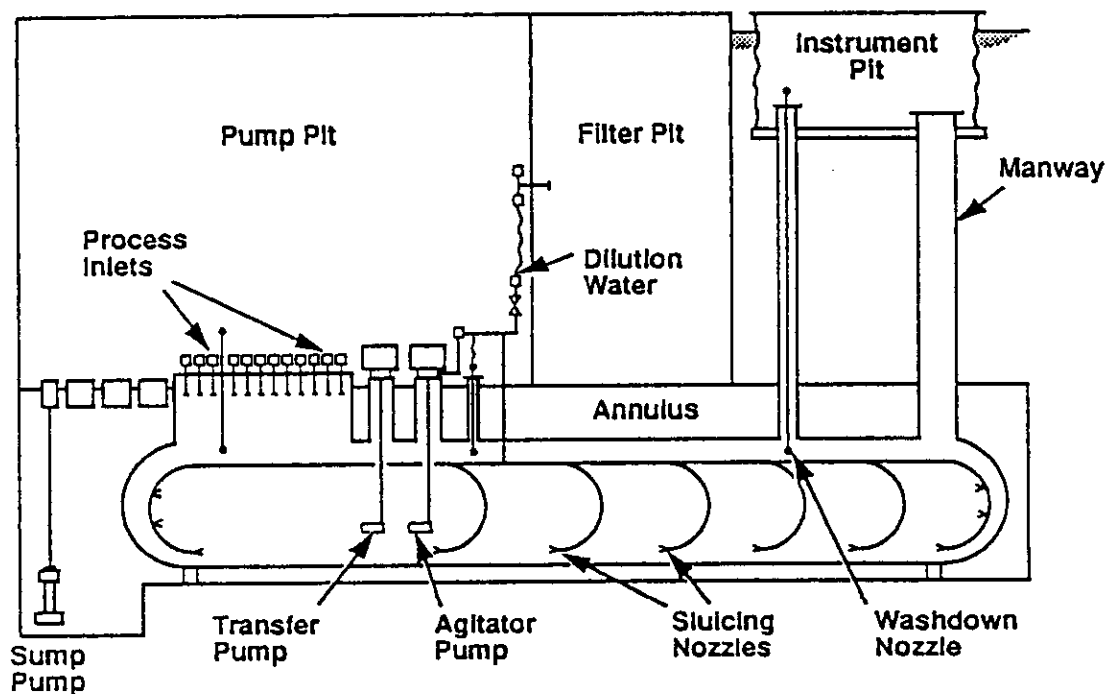
The BX-244 and TX-244 DCRTs are 25,000-gal cylindrical tanks. The tank is positioned with its axis horizontal in the lower section of a reinforced concrete vault. Above the tank vault, and connected to it, are a pump pit and a filter pit. An instrument enclosure is also above the tank vault but not connected to it.

The pump pit contains transfer and agitator pumps and jumper connections to the transfer lines and valves. The filter pit contains a ventilation system equipped with HEPA filters. The tank vault contains the receiver tank and a sump well. Associated instrumentation is contained in the instrumentation pit. Figure 4 shows the typical arrangement of the receiver vessel in its vault.

The ventilation system maintains the receiver vessel and annulus under negative pressure with respect to the atmosphere to prevent the release of radioactive materials in case of a tank breach. Supply air is taken into the

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Figure 4. Receiver Vessel, Typical Configuration.



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tank annulus through a roughing filter and a HEPA filter. The exhaust system pulls air from the annulus and the inner tank through a roughing filter and two stages of HEPA filters.

Safety considerations and controls on the ventilation systems provide dampers and valves for regulation/isolation, measurement of differential pressure across the filters, continuous radioactive particulate monitoring and record sampling of exhaust air, and continuous flow measurement of exhaust air.

Leak detectors in DCRT sumps are interlocked with the primary pumps to shut down in the event of a leak in the DCRT. Leak detectors are also installed in the filter pits.

To minimize the precipitation of solids from liquor in the piping systems, the capability of water dilution is provided in the DCRTs. In TX-244, rotating spray nozzles are installed inside the tank to aid in tank flushing. Also, sluice jets and flow from a pump agitator provide a means to resuspend solids.

3.0 IDENTIFICATION OF HAZARDS

A complete assessment of the safety of interim stabilizing the ferrocyanide tanks must examine two different sets of potential hazards:

- The hazards that could result from the change in tank contents because of interim stabilization, especially the removal of significant liquid volumes
- The hazards presented during the activities involved in the interim stabilization process (e.g., jet pumping, transfer to a DCRT).

This safety assessment examines the state of the tanks' contents after significant volumes of liquid are removed by interim stabilization. The effect of reducing the total amount of moisture in the tank on the potential reactivity of the ferrocyanide-bearing portion of the tank is examined.

Safety analysis of the interim stabilization process for SSTs, in general, is documented in various safety analysis reports (Hanson 1980 and Hanson 1981). In addition, a safety study to evaluate the adequacy of the existing safety envelope for the interim stabilization of eleven tanks not on a watchlist has been conducted (Stahl 1992a). That safety study included an independent identification of the hazards of salt well jet pumping activities for SSTs in general and identified some hazards that warranted additional analysis.

Since the potential hazards identified in those documents were judged to encompass the hazards of pumping ferrocyanide tanks, no new hazards identification was performed for this safety assessment. The potential hazards were examined to determine whether additional risks could exist because of the characteristics of the ferrocyanide tanks' contents.

3.1 POSTSTABILIZATION STORAGE HAZARDS

The hazard of concern for continued storage of the waste in the ferrocyanide tanks after interim stabilization is release of radioactive material during a pressurization of the tank caused by an energetic reaction of some of the tanks' contents. Assessing the safety of storage after stabilization requires determining whether removing significant volumes of tank liquor induces changes in the tanks' contents that make the conditions for energetic reaction more likely.

3.1.1. Ferrocyanide Reactions

The master logic diagram used for hazards assessment of interim stabilization (Coles 1992) identifies three conditions that must be simultaneously present for a release caused by a ferrocyanide/nitrate explosion to occur. They are as follows:

- Ferrocyanide and oxidant must exist in sufficient concentrations to be reactive

- Moisture associated with the ferrocyanide sludge must be insufficient to quench a reaction
- The energy balance of the reactive region must be such that temperatures high enough to initiate a reaction can be reached.

A discussion of the margins for safe storage with respect to each of these conditions follows. The effect interim stabilization is expected to have on each of these three conditions is discussed in Section 4.

3.1.1.1 Ferrocyanide/Nitrate Content. Ferrocyanide can be oxidized by nitrate in reactions that give off energy. The ferrocyanide sludges are known to contain excess nitrate. Under the proper conditions, this combination can react energetically. Of concern for the storage of wastes is the potential for a propagating reaction; that is, one that, once initiated, could release enough energy to heat the surrounding material to its ignition temperature. Tests on oxidant rich mixtures of ferrocyanide and nitrate/nitrite have placed the onset temperature of an energetic propagating reaction at about 285 °C (540 °F).

Based on the results of these analyses, the theoretical range of combinations of ferrocyanide and nitrate oxidant, water and other inert compounds for which a propagating reaction is thermodynamically possible was calculated (Grigsby 1992). The results show that for mixtures with stoichiometric ferrocyanide/nitrate mixtures (1 mol ferrocyanide:6 mol NaNO_3) less than 9 wt% of the total, a propagating reaction will not occur. This is taken as a conservative bound for safe storage.

Testing of waste simulants indicates that propagating reactions do not occur until higher ferrocyanide concentrations than those indicated by theoretical model are reached (Fauske 1992). Preliminary results of thermal testing of actual waste from Tank C-112 showed very little exothermic activity. Tank C-112 sludge is expected to contain a higher ferrocyanide concentration than the tanks addressed in this safety assessment, because it was formed by the process (In-Farm) that resulted in highest ferrocyanide concentrations. Therefore, using the results of the theoretical model to bound safe concentration is conservative.

Because the exact quantities and distribution of the ferrocyanide in the tanks are considered uncertain, a factor of safety of 3 is applied to the assumed maximum tank concentrations. Use of this factor acknowledges that uneven vertical distribution of the ferrocyanide through the sludge layer may exist. The factor of three was chosen because it is known that, for U Plant campaigns, the ferrocyanide added to the various batches was either 0.0025 mol or 0.005 mol. Allowing for the presence of more or less other precipitates that contribute to the volumes of the settled sludge and for variances in the settling characteristics of different batches a factor greater than two was chosen.

Therefore, if three times the mass of stoichiometric ferrocyanide/nitrate is less than 9% the mass of the sludge, the tank is considered safe for storage from the perspective of ferrocyanide reactivity. This is equivalent to all the ferrocyanide being concentrated in 1/3 of the sludge volume along with enough nitrate to allow it to react completely.

3.1.1.2 Moisture Removal. The primary effect of interim stabilization will be the removal of water from the tank. Most of this volume is associated with the saltcakes above the sludges. The effect of dewatering the sludge that contains ferrocyanide must be examined from the standpoint of the reactivity of the remaining mixture. Results of thermal analysis of waste simulant flowsheet sludges indicate that materials containing greater than 15% water by weight will not support a propagating reaction (Fauske 1992).

3.1.1.3 Thermal Response. The drying of the saltcakes is expected to increase their thermal resistivity. This could affect the ability of the tank to cool itself and possibly lead to increased temperatures in the sludge. A decrease in the heat load of the tank through reduction of the heat source with the pumped liquor would be expected to partially offset this effect. However, in the ferrocyanide tanks, the radioactive cesium associated with the sludge layer is expected to remain chemically bound with the ferrocyanide. Therefore, ¹³⁷Cs removal by pumping is expected to be small (about 5% of the total tank heat load based on supernate sample analysis).

As indicated above, the testing of pure ferrocyanide/oxidant mixtures found the temperature for thermal runaway to be 285 °C (540 °F). However, previous safety assessments on ferrocyanide tank activities assumed a minimum reaction temperature of 200 °C (390 °F). This is the temperature at which early testing of stoichiometric ferrocyanide/nitrate mixtures showed some exothermic behavior. For purposes of this assessment, the lower temperature will continue to be taken as a bounding temperature for safe waste storage.

3.1.2 Nuclear Criticality

Previous safety analysis reports for salt well jet pumping the SSTs have classified the potential for nuclear criticality in a tank as an incredible event. Analytical results from tank core samples consistently show fissile material concentrations at least an order of magnitude lower than the 1 g/L allowed by the criticality prevention specification. Nevertheless, concerns about the effect of removing some of the liquid moderator by pumping have led to the requirement that further pumping to achieve interim stabilization of SSTs will not occur until these effects have been evaluated (Gerton 1992).

3.2 HAZARDS DURING SALT WELL PUMPING FERROCYNANIDE WATCHLIST TANKS

A safety study was conducted by WHC to assess the adequacy of existing safety analysis for interim stabilization of tanks by salt well jet pumping (Stahl 1992a). That study included a new hazards assessment (Coles 1992), using a method different from that used in the existing safety analysis reports. The object of the new hazard assessment was to ensure that important hazards associated with the process had been identified.

The study determined that the large majority of hazards had been adequately bounded by existing safety analysis or were judged to be not credible. Five hazards remained, however, that required further detailed accident analysis. They were as follows:

- Breach of waste confinement piping or equipment in SST pump pits, DCRTs, or valve pits, resulting in a liquid spray
- Equipment fires in a SST or DCRT
- Hydrogen accumulation in DCRTs
- Waste stability following mistransfers
- Waste transfer line leaks/breaks.

The risk associated with each was quantified for a particular set of eleven tanks not on a watchlist located in three tank farms: S Farm, T Farm, and U Farm. These risk analyses were examined for this safety assessment for ferrocyanide tanks to determine whether their results bounded the risk from the same hazards in the ferrocyanide tanks under consideration for interim stabilization. The analyses and their applicability to the ferrocyanide tanks are discussed in Section 4.2.

4.0 HAZARD ANALYSIS

4.1 POSTSTABILIZATION STORAGE

Evaluation of the safety of storage in the ferrocyanide tanks after pumping focuses on the changes in the ferrocyanide sludge layer that might be expected as a result of interim stabilization. For reasons discussed in the following sections, it is anticipated that interim stabilization of all the tanks can be completed without changing the ferrocyanide content and moisture content of the sludge layer. In the tanks with significant saltcake overburden, a temperature rise (<30 °F) in the sludge can be expected. However, temperatures are expected to remain below 160 °F, well below the ignition temperature.

4.1.1 Ferrocyanide/Nitrate Concentrations

The best available estimates of the ferrocyanide inventories and ferrocyanide sludge volumes in these tanks come from a model that was based on the records of the ferrocyanide scavenging campaigns (Borsheim 1991). The model provides estimates of the quantities of ferrocyanide and ¹³⁷Cs and volumes of sludge that were in each tank at the end of the ferrocyanide scavenging campaign. These values were adjusted to account for subsequent transfers of ferrocyanide sludge between tanks. If it is assumed that the saturated saltcake from the concentration process did not mix appreciably with

the ferrocyanide layer, diluting it with respect to the ferrocyanide concentration, then the composition of the sludge can conservatively be taken to be the same now as it was then.

The tank liquors to be removed by salt well jet pumping are not expected to remove appreciable amounts of ferrocyanide from the sludge. The majority of liquor that drains into the salt well is from the saltcake.

Liquid samples from three BY tanks show cyanide ion (CN^-) concentrations at 7, 14, and 45 ppm (see Table 1). No specific chemical analysis for ferrocyanide ion in the samples has been performed. However, assuming that the cyanide is all derived from ferrocyanide present in the sample, the $\text{Fe}(\text{CN})_6^{4-}$ concentration in the liquor samples would be between 9 and 60 ppm. For the tank with the greatest amount of pumpable liquor, the maximum amount of ferrocyanide removed would be less than 100 g or about 0.5 mol. Therefore, the analysis of the state of the waste remaining in the tanks after pumping assumes that all the ferrocyanide remains in the sludge layer in the tank.

Table 2 lists the ferrocyanide tanks requiring interim stabilization with an estimation of the bulk ferrocyanide concentration in the sludge layer. The table gives values for sludge with assumed 40 wt% water and for dry sludge. The ferrocyanide content and sludge volumes were based on the historical model discussed above. Other assumptions used for the calculations are that the ferrocyanide is $\text{Na}_2\text{NiFe}(\text{CN})_6$, the most abundant ferrocyanide species in the tanks, and that the sludge density is $1,500 \text{ kg/m}^3$. The density value is consistent with values determined from sludge samples taken from TY Tank Farms (Grigsby 1992).

Table 2. Bulk Ferrocyanide and Oxidant Concentrations in Tanks Requiring Stabilization.

Tank	Ferrocyanide concentration (wt%)		$\text{Na}_2\text{NiFe}(\text{CN})_6 + 6 \text{ NaNO}_3$ (wt%)	
	40% Water	Dry	40% Water	Dry
BX-106	0.18	0.3	0.47	0.8
BX-110	0.03	0.05	0.08	0.13
BX-111	0.08	0.14	0.21	0.4
BY-103	1.8	2.9	4.6	7.6
BY-105	0.94	1.6	2.5	4.1
BY-106	1.7	2.8	4.4	7.4
T-101	0.05	0.09	0.14	0.2
T-107	0.13	0.22	0.35	0.6

The history of ferrocyanide campaigns and waste transfers indicates that tanks BX-106, BX-110, BX-111, and T-101 probably do not contain appreciable amounts of ferrocyanide and were placed on the watchlist on the basis of inaccurate inventory data. For these tanks, the calculations of sludge contents assumed 1,000 mol of ferrocyanide in the tank, the minimum amount that is the basis for watchlist status.

If the dry ferrocyanide/oxidant estimates are multiplied by a factor of three to allow for uncertainties in the inventory model or for possible uneven distribution of ferrocyanide in the sludge, five of the tanks (BX-106, BX-110, BX-111, T-101, and T-107) still fall below the maximum concentration limit of 9 wt% discussed in Section 3.1.1.1.

4.1.2 Moisture Removal

Sample analyses of tanks containing ferrocyanide in the TY Tank Farm indicate that the minimum water content of the sludge was about 40 wt% (Grigsby 1992). These analyses were made in 1985, about two years after the tanks were interim stabilized by salt well jet pumping. Analysis of waste simulant mixtures made up in the laboratory using the original scavenging recipes confirms that the moisture content of the sludges remains high (>60 wt% for U Plant materials) after compaction by centrifuge to simulate long-term settling (Bechtold 1992).

The volumes of liquor expected to be removed by pumping are calculated based on an assumption that 12.5% of the sludge volume contains free liquid that will drain. An additional assumption is that there is a 2-ft liquid heel at the tank bottom that is held in the sludge by capillary forces. Estimation of expected capillary hold-up height based on average measured surface median particle size diameters of ferrocyanide sludge samples (Grigsby 1992) indicate that for ferrocyanide sludges, the expected capillary height is greater than the 2 ft generally assumed for Hanford Site tank sludges. Hydraulic testing of waste simulants (Wong 1992) indicates particle sizes less than 60 microns for U Plant simulants, with 97% of the mass less than 2 microns in diameter. The material was found to have coefficient of permeability of 5.1×10^{-6} cm/s. These properties are those typically measured in silts and clays. Therefore, the liquid is expected to be undrainable for the sludge heights observed in any of these eight tanks.

In fact, ferrocyanide tanks that have already been salt well jet pumped to meet the low pump flow criterion show interstitial liquid levels substantially greater than the expected 2-ft capillary heel (Klem 1990). Table 3 shows the expected ferrocyanide sludge heights (Borsheim 1991) and the measured interstitial liquid levels in the waste remaining in the ferrocyanide tanks that have been jet pumped.

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Table 3. Ferrocyanide Sludge Heights and Interstitial Liquid Levels in Previously Stabilized Tanks.

Tank	Sludge height (in.)	Interstitial liquid level (LOW) (in.)	Liquid height above (below) sludge (in.)
BY-101	<12	59 to 67	47 to 55
BY-104	102	80 to 84	(18 to 22)
BY-107	65	61 to 67	(2) to 4
BY-110	89	71 to 74	(15 to 18)
BY-111	12	48 to 82	36 to 70
BY-112	8	34 to 37	26 to 29
TX-118	<12	53 to 58	41 to 46
TY-103	72	49 to 59	(13 to 23)

All the tanks show interstitial liquid levels greater than 2 ft. In the tanks where the remaining interstitial liquid is all in the sludge layer, the minimum liquid level is about 4 ft. In all cases where the interstitial liquid level is below the sludge level, it is less than 2 ft below it. Therefore, if jet pumping is continued until the low pump flow criterion is reached, it is expected that most, if not all, of the ferrocyanide remaining in the tanks following salt well jet pumping will be saturated with liquor.

Table 4 lists the ferrocyanide tanks that are candidates for interim stabilization with the estimated sludge height for each and an estimate of the amount of sludge that would be less than saturated if a 2-ft and a 4-ft capillary heel is assumed.

Table 4. Anticipated Unsaturated Sludge Volumes Following Stabilization.

Tank	Sludge height (in.)	Volume of sludge not saturated (kgal)	
		2-ft Capillary heel	4-ft Capillary heel
BX-106	<12	0.0	0.0
BX-110	<12	0.0	0.0
BX-111	<12	0.0	0.0
BY-103	84	165	99
BY-105	42	50	0.0
BY-106	90	182	115
T-101	<12	0.0	0.0
T-107	84	165	99

The tanks that would be left with a portion of the sludge layer less than saturated if a 4-ft capillary heel is assumed are BY-103, BY-106, and T-107. It is expected, from the evidence discussed above, that the sludge above the interstitial liquid level will still contain at least 40% moisture. However, if an extra measure of conservatism is desired, the pumping could be halted sometime before the top of the sludge is reached. The interstitial liquid in the sludge would be within the 50,000-gal limit required for interim stabilization.

4.1.3 Ferrocyanide Sludge Temperatures

The temperature histories of ferrocyanide tanks that have been interim stabilized by salt well jet pumping indicate that significant long-term temperature rises have not occurred as a result of jet pumping (Kimura 1990). Table 5 lists the ferrocyanide tanks that have been interim stabilized by salt well jet pumping with maximum annual tank temperatures before and after jet pumping. The shaded areas indicate the year that jet pumping was completed. The values in the table are from manual thermocouple readings taken monthly before 1990 and weekly thereafter.

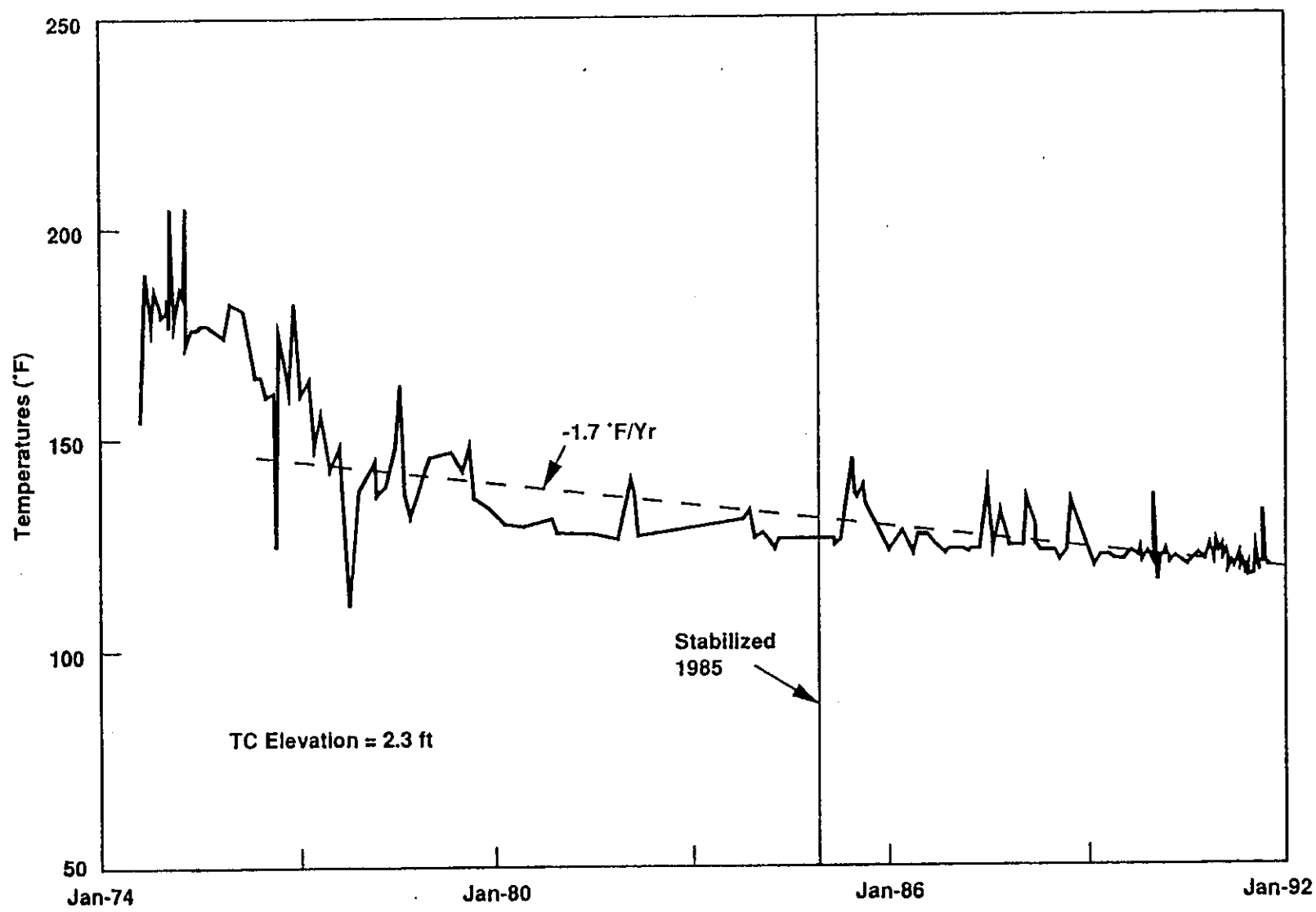
Table 5. Temperature History of Stabilized Ferrocyanide Tanks.

Tank	Highest yearly temperatures (°F)												
	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92
BY-101		75	96	72	84						76	76	75
BY-104	170	145	164	145	143	158	145	149	136	148	130	129	129
BY-107*											86	94	97
BY-108	117	96	119	118		97					103	102	92
BY-110	139	132	118	147	148	140	145	139	133	136	135	120	122
BY-111						97					87	83	87
BY-112		93				93					84	82	83
TX-118			100	108	85	89					78	78	77
TY-101	80	62	78	68				68	79		71	71	71
TY-103	69	75		64			65				69	69	67

Shaded areas indicate the year the tank was jet pumped.

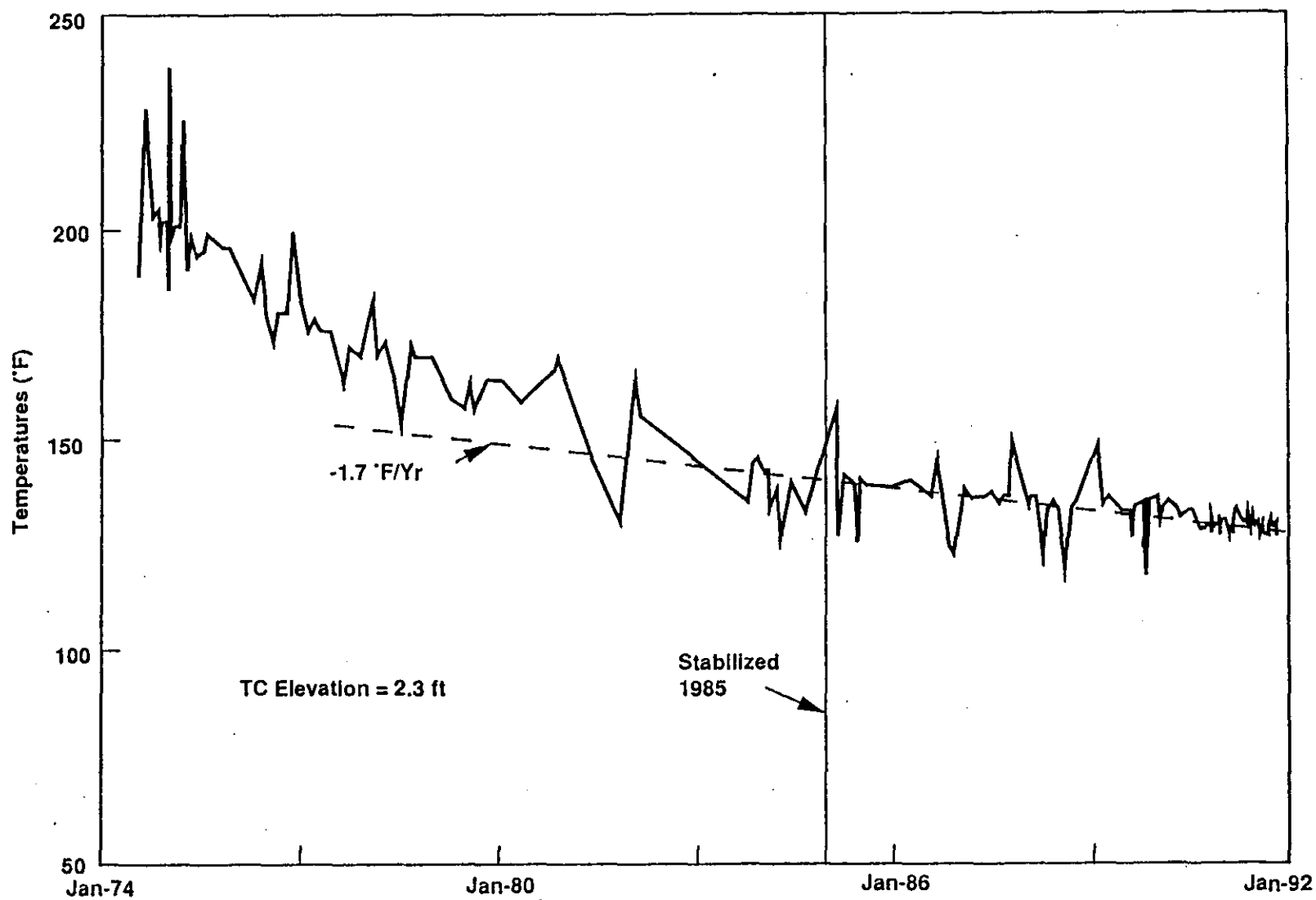
*Tank BY-107 was jet pumped in 1979.

The two tanks with highest temperatures, tanks BY-104 and BY-110, are also the tanks for which periodic temperature data, recorded over the years before and after jet pumping, are available. Temperature plots over time for these two tanks are shown as Figures 5 and 6 for a thermocouple within the sludge layer (2.3-ft elevation). Both tanks have an overlying saltcake layer. In both cases there is a continual downward trend in temperature consistent with the decrease, from nuclear decay, of the major heat sources in the tank.



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Figure 5. Tank 241-BY-104 Temperature.



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Figure 6. Tank 241-8Y-110 Temperature.

The apparent increasing temperature trend since 1990 in Tank BY-107 seems to be an artifact of connecting the thermocouple tree to a CTMS in late December 1991. The manually recorded temperature readings from the two thermocouples closest to the tank bottom (TC1 and TC2) showed an increase of about 15 °F thereafter. Automatically recorded temperature traces for the first six months of 1992 show that TC1 has fluctuated between 94 and 100 °F during that time.

The maximum expected temperature rise in any tank resulting from dryout of the saltcake can be estimated from the current steady state temperature change across the wet saltcake and the expected change in saltcake thermal conductivity. Of the seven tanks examined in this study, Tank BY-106 has the highest temperature as well as the greatest temperature difference across the saltcake layer. Therefore, it is taken as the worst-case tank from the standpoint of anticipated maximum temperature rise after pumping.

If the thermal conductivity of the saltcake layer is decreased by 1/2 because of moisture removal, then the temperature difference across the saltcake would be expected to double, all other parameters remaining equal. In fact, the thermal conductivity of dry saltcake has been conservatively estimated to be about 60% that of wet saltcake (McLaren 1991).

December 1991 temperature measurements from Tank BY-106 indicate that the temperature difference across the saltcake layer (16.6 ft) is about 40 °F, and the maximum tank temperature is 130 °F. The expected temperature difference, with the lower thermal conductivity, would be about 70 °F ($40\text{ °F}/0.6$). This translates to a maximum sludge temperature of 130 °F plus 30 °F ($70\text{ °F} \text{ minus } 40\text{ °F}$) or 160 °F (70 °C). This is well below the minimum temperature of concern for initiating a ferrocyanide propagating reaction even given optimum ferrocyanide, oxidant, and moisture content.

Neither the history of temperature response from interim stabilized ferrocyanide tanks with saltcake layers nor the physical response of the tank expected from drying the saltcake supports the proposition that pumping would cause temperatures of concern in the ferrocyanide sludge. Therefore, it is concluded that the likelihood of achieving high enough temperatures to initiate an energetic ferrocyanide reaction is extremely low.

4.1.4 Conclusions

Table 6 lists the eight ferrocyanide tanks that are candidates for interim stabilization, along with an evaluation of the status of each tank with respect to ferrocyanide concentration, moisture content, and expected temperature rise in the sludge. It is concluded that for any tank that is conservatively estimated to meet two of the three criteria established in Section 3.0, the hazard of airborne release from a ferrocyanide/nitrate reaction can be ruled out.

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Table 6. Summary of Conditions in Tanks After Stabilization.

Tank	Ferrocyanide/nitrate concentration <3 wt%	Sludge fully saturated with liquid	Temperature rise above 200 °C not possible
BX-106	Yes	Yes	Yes
BX-110	Yes	Yes	Yes
BX-111	Yes	Yes	Yes
BY-103	No	No	Yes
BY-105	No	Yes	Yes
BY-106	No	No	Yes
T-101	Yes	Yes	Yes
T-107	Yes	No	Yes

A high degree of conservatism has been built into the criteria. This is to provide a safety envelope large enough to bound the uncertainties in the state of the tanks arising from uncertainties in tank inventories and distribution of components in the sludge layer. The conservative aspects of the criteria are reiterated below.

1. The criterion for ferrocyanide/oxidant concentration is based on a very conservative thermodynamic analysis. Thermal testing of actual tank sludge samples would give a more realistic estimate of actual maximum safe concentrations. If the factor of safety applied to tank inventories were removed, all the tanks would fall below the criterion limit.
2. The requirement for saturation of the sludge ignores the confidence provided by sample data and testing of waste simulant materials that the sludges retain at least 40 wt% moisture without heat input sufficient to release it.
3. The choice of 200 °C as the maximum allowable temperature for the sludge is very conservative because testing on dry waste simulants shows that propagating reactions require much higher initiating temperatures.
4. Each of the three criteria, taken separately, should be enough to ensure against an energetic reaction. The requirement that a tank meet at least two of the criteria provides an extra margin of safety.

It can be seen from the table that tanks BX-106, BX-110, BX-111, BY-105, T-101, and T-107 fall within the established criteria and can be considered safe for pumping. Tanks BY-103 and BY-106 can be brought within the margins if pumping is stopped when the interstitial liquid level reaches the sludge height. This would leave maximum drainable liquid in the tanks of 18,000 and 20,000 gal respectively (assuming the drainable liquid volume fraction of the sludge is 0.125). These volumes are well within the established criterion

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(less than 50,000 gal drainable interstitial liquid) for declaring a tank interim stabilized.

Therefore, it is recommended that jet pumping on these two tanks be stopped when the interstitial liquid level, as measured at the LOW, is at the calculated sludge height. If evidence from the hydraulic testing of waste simulants and sampling of previously stabilized tank sludges provide greater assurance of the intrinsic ability of the ferrocyanide sludges to retain well above 15 wt% water, this recommendation can be relaxed.

4.2 HAZARD ANALYSIS FOR INTERIM STABILIZATION ACTIVITIES

The *Safety Study of Interim Stabilization of Nonwatchlist Single Shell Tanks* (Stahl 1992a) identified safety issues already adequately evaluated in previous safety documentation for SSTs as well as other new issues that require further action to support an educated decision on the safety of interim stabilization activities. The approach used in conducting the safety study was to evaluate the adequacy of applicable existing safety studies and identify and determine the significance of hazards associated with the pumping process. Detailed accident analysis was performed and conclusions derived regarding the risk from stabilizing a specific set of tanks not on a watchlist. Recommendations for improved controls were formulated with the consideration given to the hazards and existing controls and risk acceptance evaluation results.

The facilities and equipment included in the study were those associated with the SSTs, the salt well jet pump equipment and jumper assemblies, pump pits, valve pits, DCRT, waste transfer line piping and associated instrumentation, alarms, safety interlocks, and control equipment. Processes and controls evaluated included those associated with the interim stabilization process preparation, startup, pumping, and postpumping monitoring. Waste stability issues were also evaluated as they apply to tanks not on a watchlist, facilities, and equipment. The watchlist issues of flammable gas generation, high heat, organics, ferrocyanide, and criticality were evaluated for their potential applicability to the wastes within the designated or inadvertent receiving vessels.

4.2.1 Application of Pumping Study to Ferrocyanide Tanks

The eight ferrocyanide watchlist SSTs (241-BX-106, -110, -111; 241-BY-103, -105, -106; 241-T-101, -107) proposed for interim stabilization are in three tank farms; BX Farm, BY Farm, and T Farm. A waste transfer procedure specific to the tank farm to be pumped will have to be available before initiation of pumping the specified tanks in BX, BY, and T Tank Farms. For the study of tanks not on a watchlist, these procedures were not available and, therefore, the study (Stahl 1992a) assumed that the routes used would be similar to the routes presently defined in the *Single Shell Tank Leak Emergency Response Guide*. (Lo 1991)

Since the emergency response guide describes pumping routes for all SST farms including the BX, BY, and T farms, it is expected that pumping routes for the watchlist and nonwatchlist tanks will be similar and that the

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facilities and equipment included in the nonwatchlist study are, therefore, representative of pumping watchlist tanks.

Furthermore, the master logic diagram (MLD) for the tanks not on a watchlist (Coles 1992) considered airborne releases from ferrocyanide explosions outside the SSTs. It hypothesized that without comprehensive physical sampling of the tank waste there is some uncertainty about the makeup of the waste and, therefore, it can be assumed explosive substances can exist. However, the possibility of ferrocyanide explosion was discounted since waste material hot spots were not considered credible outside the SSTs and the moisture content inside the DCRT would be too high. (Stahl 1992b)

Since the safety study of the tanks not on a watchlist concludes that a ferrocyanide explosion is incredible ($<10^{-6}$ events/year) outside a SST even when a potentially explosive substance exists in the tank, the same conclusion is applicable to the ferrocyanide tanks. In addition, analyses of supernate samples from the BX and BY tanks (see Table 1) indicate very low potential for significant ferrocyanide content of the pumped liquor. Therefore, the potential for an explosive ferrocyanide mixture outside the tank is eliminated.

4.2.2 Analysis of Special Hazards Identified by Safety Study

The risk assessment and accident consequence analysis for the special hazards identified in the *Safety Study of Interim Stabilization of Nonwatchlist Single Shell Tanks* (Stahl 1992a) were examined for their relevance to the ferrocyanide tanks. A discussion of each follows.

Spray Leak--The event analyzed was a spray leak from a breached jumper connector in a DCRT pump pit. The most significant factor contributing to potential consequences from the leak was determined to be the possibility of the breach occurring while a cover block was not in place. The frequency of this event was evaluated as 0.011 events/year for the 244-TX DCRT. The frequency for 244-BX is expected to be the same because the DCRT configurations are the same.

The maximum dose consequences for a spray leak while the cover block was not in place were found for the U Farm. The consequence was 13.0 rem effective dose equivalent (EDE) to the onsite individual and 5.4×10^{-2} rem EDE from inhalation offsite. The onsite dose was reduced to insignificant if the cover block was assumed to be in place to contain the leak.

The source term for the dose consequence analysis is based on the radionuclide content of the pumped liquor. The values used for the analysis of the U Farm tanks are greater than those determined for the supernate samples from the ferrocyanide tanks. Therefore, the risk analysis for a spray leak event during pumping of one of the eight ferrocyanide tanks is bounded by the analysis performed to evaluate this event for tanks not on a watchlist.

Equipment Fire--Event tree analysis demonstrated that end-state conditions resulting from equipment fires were bounded by existing safety analysis. Examination of other fire related events in SSTs and DCRTs led to the conclusion that none were credible. It is concluded that existing safety

analysis bounds the risk and consequences for equipment fires in the ferrocyanide tanks.

Hydrogen Accumulation in DCRTs--The evaluated frequency of a fire or explosion because of hydrogen accumulation in a DCRT was the same, 0.34 events/year, for all DCRTs considered. Therefore, it is not expected to be different for the tanks considered in this safety assessment.

The dose consequences from a hydrogen explosion in the 244-TX DCRT were 0.23 rem EDE onsite and 3.3×10^{-4} rem EDE offsite. Since the configuration of the 244-BX DCRT is the same as the 244-TX DCRT, the analysis is valid for the ferrocyanide tanks covered in this study, with only the source term differing.

The source term is determined by the hydrogen generation rate and the concentration of radionuclides in the material released from the tank. Both of these factors are a function of the radionuclide content of the liquid contents of the tank. Therefore, the consequences of a hydrogen explosion in the DCRT for the eight ferrocyanide tanks are expected to be lower than those calculated for the tanks not on a watchlist because the radionuclide content of the pumped liquor is lower for the ferrocyanide tanks.

Waste Stability--The safety study for stabilization of tanks not on a watchlist concluded that there is no increase in risk or any dose consequences expected as a result of inadvertent addition to a tank because of mistransfer or drainback during pumping. The same is expected to be true for the ferrocyanide tanks because no appreciable ferrocyanide is present in the liquor.

Waste Transfer Line Leaks/Breaks--The frequency and consequences of leaks to the ground from transfer line breaks during pumping were calculated for the tanks not on a watchlist. The frequencies for the maximum release from pumping the BX and BY tanks are expected to be similar to those in the T and U farms. The consequences are bounded by those analyzed because of the lower source term.

Consequently, stabilization of the ferrocyanide watchlist tanks by jet pumping is judged to be adequately bounded by the existing safety analysis and the safety study for stabilizing tanks not on a watchlist.

5.0 CONSEQUENCES OF ACCIDENTS

No new accident consequences were calculated as a result of this safety assessment. Consequences of likely accident scenarios during the jet pumping process have been calculated as part of other safety analyses (Hanson 1980, Hanson 1981, and Stahl 1992a).

It is judged to be extremely unlikely that all the conditions required for propagating an energetic ferrocyanide reaction exist simultaneously in any of the ferrocyanide tanks addressed in this safety assessment. Salt well jet

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pumping is not expected to increase the likelihood of the event because changes in the composition of the ferrocyanide sludge are not expected.

6.0 CONTROLS

Procedures and operational safety requirements for interim stabilization of SSTs are in place. Salt well jet pumping of the tanks will not be performed until the administrative hold imposed by the JCO for the nuclear criticality USQ is lifted.

The *Safety Study for Interim Stabilization of Nonwatchlist Tanks* (Stahl 1992a) identified two accident scenarios, spray leaks and DCRT hydrogen accumulation, for which the potential dose consequences to onsite personnel exceed risk comparison guidelines. That document recommended controls that would reduce the consequences to acceptable levels. Those controls shall be required for interim stabilization activities in the ferrocyanide tanks. They are as follows.

- Ensure that all cover blocks are in place on all facilities (including SST pump pits, valve pits, and DCRTs) before initiating pumping and that no cover blocks are removed until pumping through the affected facility is shut down. Ensure that cover blocks are properly reinstalled after maintenance activities before pumping is resumed.
- Ensure that DCRT ventilation systems are operational and continually operated at a flow rate great enough to ensure complete mixing in the freeboard space during all waste transfers and retentions in the affected DCRT.

A control is required to preserve the conservatism of the analysis of the potential hazard posed by the reactivity of the tank contents.

- For tanks BY-103 and BY-106 monitor liquid level at the LOW and discontinue pumping when the interstitial liquid level reaches the sludge level. If future testing of waste simulants and tank samples provides more confidence in the capability of the ferrocyanide sludge to retain significant moisture, or that the sludge in these tanks is nonreactive, this requirement may be relaxed.

Additional controls imposed by previous safety assessments for ferrocyanide tank activities shall be followed (Farley 1992). These controls apply whenever tank confinement is opened to the atmosphere (e.g., opening a riser or uncovering the pump pit for pump installation or maintenance). The controls address potential hazards to workers presented by flammable or toxic gases that might be present in the tank atmosphere.

- Before salt well pump installation in a ferrocyanide tank, the tank vapor space gases shall have been sampled and analyzed to determine toxic and flammable constituents. Standard tank farm methodology shall be used as defined by the Industrial Hygiene and Safety

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organization. The sampling procedure must have occurred within a year prior to pump installation.

- Contamination control shall be provided around the pump pit or opened riser. The means of contamination control shall be specified by a Health Physics Technician.
- Personnel breaking confinement shall be on supplied fresh air. Personnel within 28 ft of an open riser or other release point shall be supplied fresh air. Respiratory protection for other personnel in the tank farm will be as specified by the Industrial Hygiene and Safety organization.
- Before opening the pump pit or any riser, combustible gas shall be measured at the HEPA exhaust. After the bolts holding the riser flange are loosened enough to take a gas sample from the riser, but before complete removal of the riser cover, another gas sample shall be taken at the top of the riser. After flange cover removal, a sample shall be taken in the tank vapor space below the riser. This shall be done with an Industrial Scientific Model MX241 or MX251 (or equivalent) flammability meter calibrated on a methane standard. If the combustible gas level is greater than 20% of the lower flammability limit (LFL) at any of the three locations, pump installation activities shall not proceed.
- After riser cover or pump pit cover removal, readings for toxic gas shall be made at the opening by a field representative from the Industrial Hygiene and Safety organization. Readings for toxic gas in the worker breathing zone shall also be made every 15 minutes, whenever the pump pit or a riser is open. Because of the nature of the waste in the tank, gas monitoring shall include testing for hydrogen cyanide and hydrazine in addition to the gases normally monitored (e.g., ammonia, nitrous oxide, nitrogen dioxide, organic vapors, hydrogen)
- The equipment installation and operation procedures (along with this safety assessment) shall be reviewed by Radiation Protection personnel to determine specific radiation protection requirements. A job hazard review shall also be performed by Industrial Safety.


The controls and operating conditions discussed in this section must be addressed in the procedures, work package, training and other appropriate documentation, and observed in conducting the work. Preparation for interim stabilization of ferrocyanide tanks shall include a review of this safety assessment and other applicable safety documentation to ensure the continued validity of the analysis in light of increased understanding of the tanks' contents and of changes in the equipment or process.

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